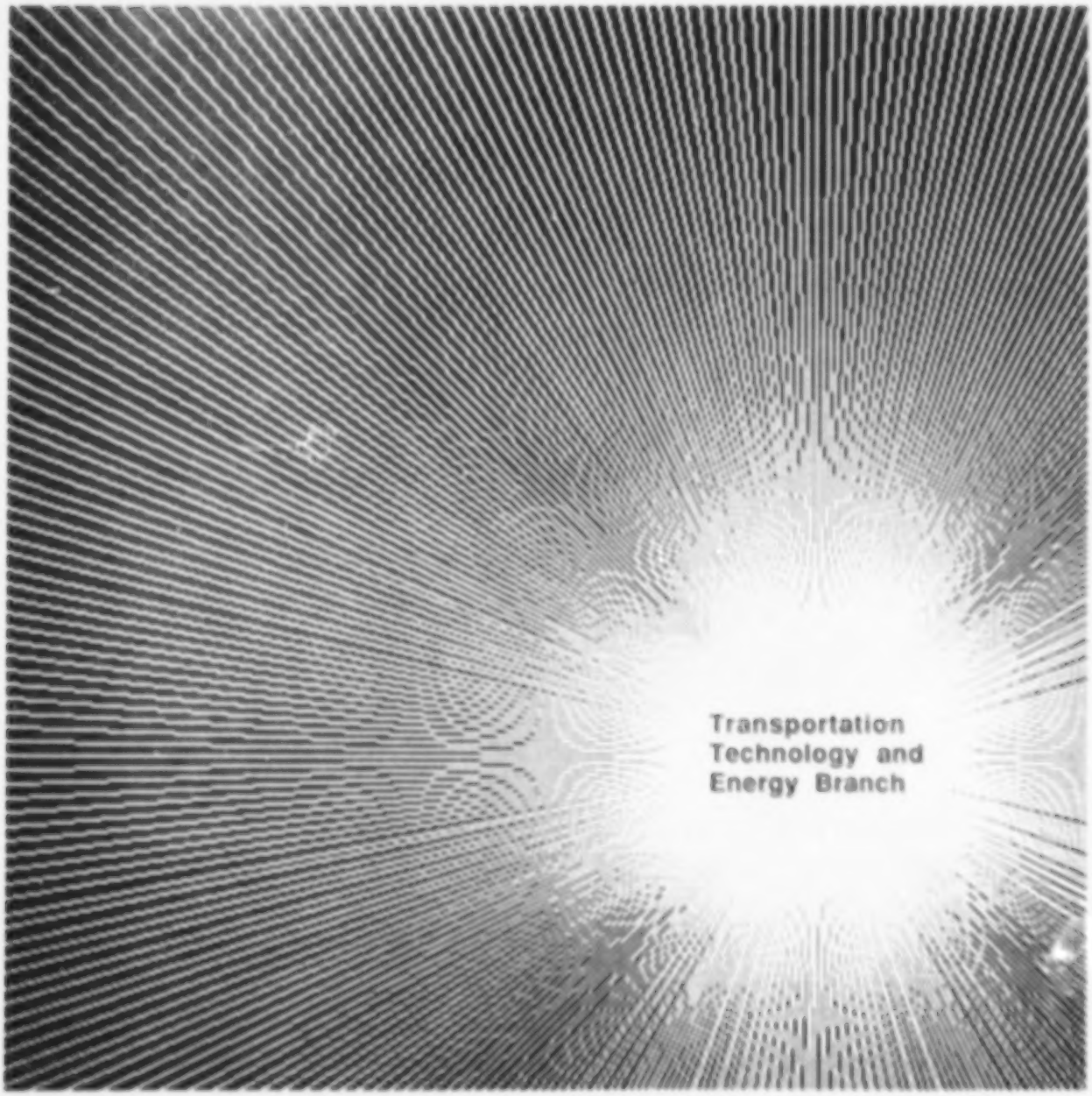
Ontario

Ministry
of
Transportation

Transportation
Technology and
Energy Branch



92-00814/

Transportation, Energy and the Environment: Things Are Heating Up

AT-91-03

AT-91-03

Transportation, Energy and the Environment: Things Are Heating Up

M.D. Harmelink
Director, Transportation Technology and Energy Branch

O.M.S. Colavincenzo
Manager, Vehicle Technology Office

This paper was presented to TAC
Transportation and Energy Workshop
Winnipeg
September 18, 1991

Published by:

Transportation Technology and Energy Branch
Ministry of Transportation of Ontario

Published without prejudice as to the application of the findings. Crown copyright reserved; however, this document may be reproduced for non-commercial purposes with attribution to the ministry.

For additional copies, write:
Technical Publications (TT&E Branch)
Ministry of Transportation of Ontario
Room 321, Central Building
1201 Wilson Avenue
Downsview, Ontario
Canada M3M 1J8
(416) 235-3466

November 1991

1/ BACKGROUND

An efficient and effective transportation system has been and is important to the development of the Canadian economy. Recently, transportation has come to be viewed as causing damage to the environment and accelerating the depletion of our energy resources. It is the challenge placed on transportation by the latter two additional views that this paper addresses.

Transportation provides the linkages and vehicles to move people and goods from their origins to their destinations. We can expect that the demand for transportation services will continue to grow as the economy expands. Recent data from the U.S. and from Ontario suggest that vehicle miles travelled (VMT) will continue to grow at an annual rate of approximately 2% per annum over the next 20 years. It will be slightly higher for the first decade and slightly lower for the second. Some of the factors driving this growth are related to population growth, two-worker households, economic expansion and dispersion of residential and employment centres.

The increasing demand for transportation results in increasing demand for energy and an increase in the production of emissions. In reviewing the 1985 Canadian sectoral emission contributions to the environment, it is found that emissions from road transportation contributed approximately 30% to volatile organic compounds (VOCs), 40% to oxides of nitrogen (NO_x), 95% to carbon monoxide (CO), and 18% to carbon dioxide (CO_2). Clearly, these contributions are large and every effort should be made to reduce them [1,2].

Some of the means that governments, transportation experts, and industry can use to reduce the production of these emissions are technology, planning and lifestyle changes, standards, and taxation. The effectiveness and impact of these measures are discussed below.

2/ SOURCES AND IMPACTS OF EMISSIONS

Except for some minor exceptions, the main energy source for transportation vehicles is petroleum. Some of the trends for energy consumption in Canada and Ontario are shown in Figure 1. Energy consumption is projected to increase at approximately 1.5% per year for Canada and 1.8% per year for Ontario. The small difference between projected Canadian VMT growth of 2% and energy consumption growth of 1.5% may be a reflection of some efficiency improvements. While energy consumption continues to grow, the production of emissions from road transportation shows different trends, depending on the emission. The trends for the main emissions from vehicles, i.e., CO_2, NO_x and VOCs, are reviewed below.

The largest emission from transportation is CO_2 and its contribution to global warming is 49%. The other contributors to global warming are methane 18%, chlorofluorocarbons 14%, nitrous oxide 6%, and other trace gases 13%.

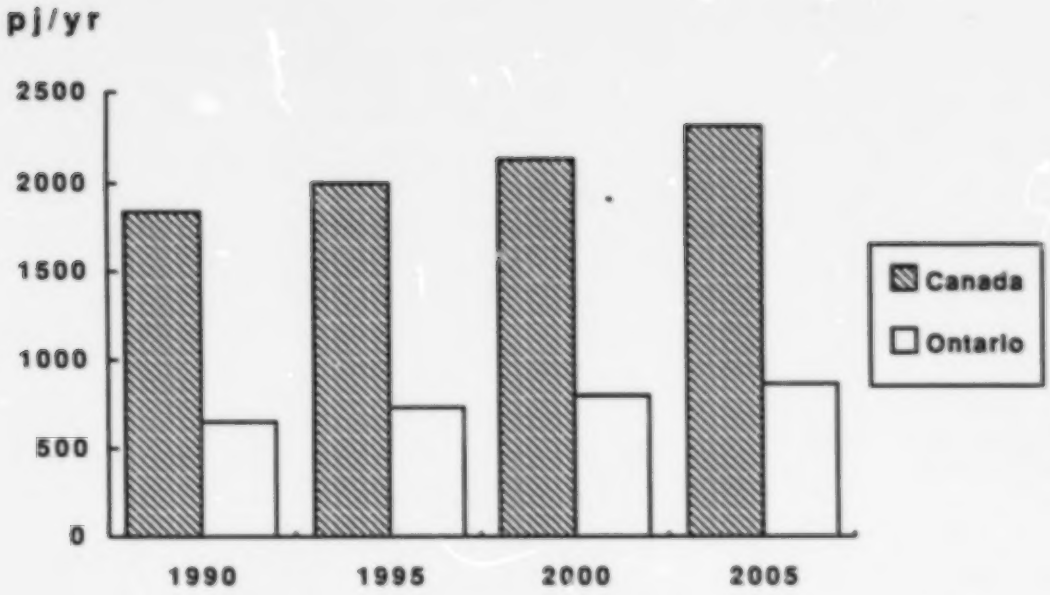


Figure 1/ Projected Transportation Energy Demand for Canada and Ontario

The production of CO_2, the principal greenhouse gas, increases with the projected increase in energy demand. The projection for CO_2 production from all transportation, i.e., light duty vehicles (LDV), heavy duty vehicles (HDV) and others, from 1990 to 2005 is shown in Figure 2 for Ontario. These results are taken from a joint study on behalf of the Ministry of Transportation, the Ministry of the Environment, and the Ministry of Energy [3]. Transportation's total contribution to CO_2 production in Canada was 25% in 1988 and is projected to maintain that share.

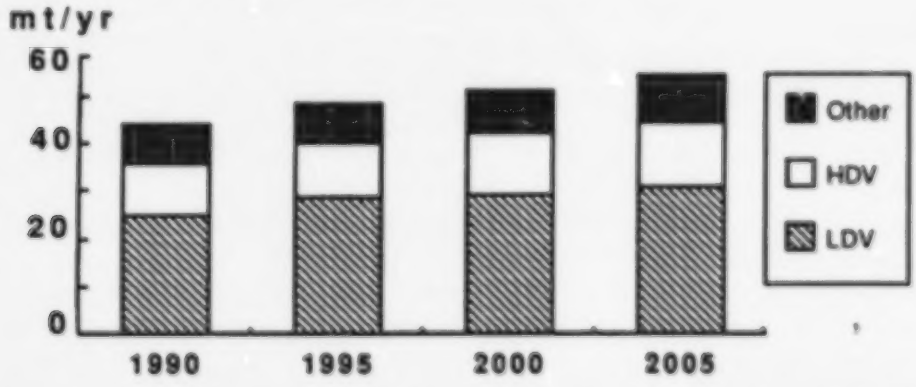


Figure 2/ Annual Carbon Dioxide Emissions in Ontario From Transportation

Within the transportation sector, the projection for the production of CO_2 from light duty vehicles indicates that its growth slows after 1995. On the other hand, CO_2 production from heavy duty vehicles increases. The light duty vehicle trends reflect some efficiency gains while the expansion in the heavy duty truck segment is a reflection of continued economic expansion and the increased need for goods movement.

In the future it is likely that the production of CO_2 by every country will be scrutinized as the world tries to develop an equitable policy to control its production. Two of the common indicators used to assess a country's efficiency in minimizing the production of CO_2 are mass of CO_2 emissions per capita and mass of CO_2 emissions per unit of gross domestic product. Figures 3 and 4 show where Canada stands using these two figures of merit. The data were compiled by the Organization for Economic Cooperation and Development (OECD) and published in summary format [4].

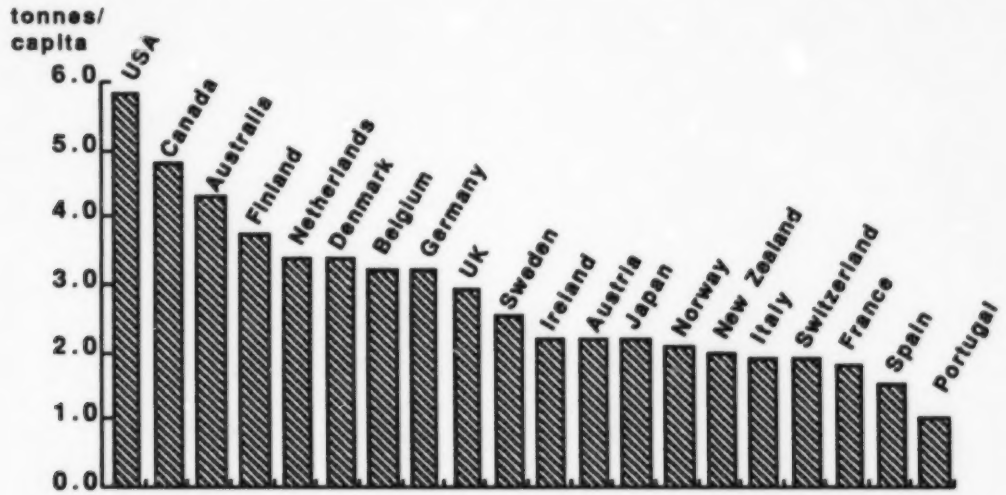


Figure 3/ Carbon Dioxide Production Based on Population

On a per capita basis, Canada ranks second among OECD countries for production of CO_2. One explanation for this is that Canada exports much of its natural resources and the energy required to produce the exports are attributed to Canadians. Since the natural resources industry is an energy intensive sector and our population is relatively small, Canada's high per capita production is not necessarily an indication of an inefficient economy.

A better indicator of the efficiency of a country's industry is the mass of CO_2 produced per unit of gross domestic product. Using this criterion Canada ranks eighth. It should be noted that on this basis Canada still uses 1.75 times as much energy to produce a unit of gross domestic product as Japan. The factor that relates Figures 3 and 4 is gross domestic product (GDP) per capita. For the U.S., Canada, and Japan the GDP per capita is $18,125, $15,000, $12,000 respectively.

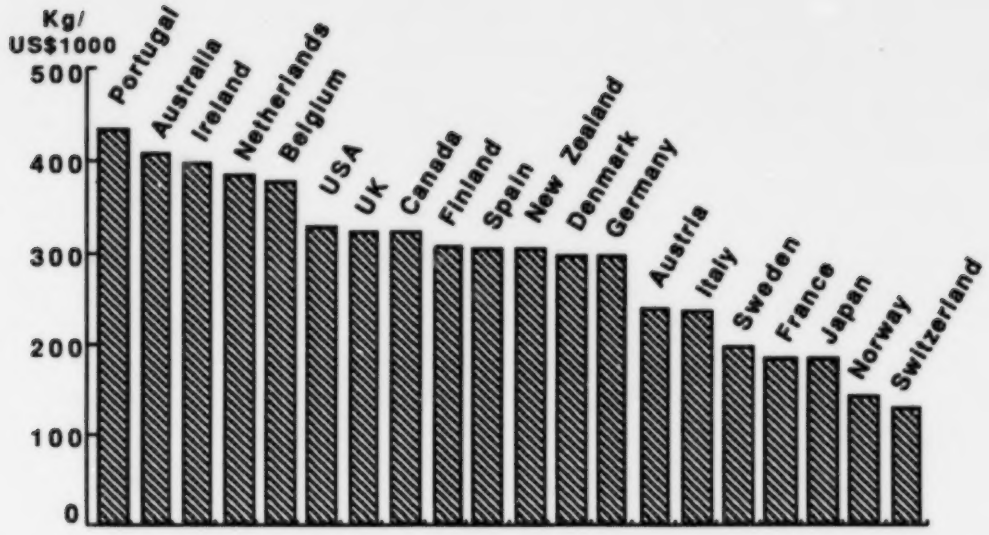


Figure 4/ Carbon Dioxide Production per Unit of Gross Domestic Product

The other transportation pollutants of interest are those associated with the production of ozone and acid rain, i.e., VOCs and NO_x. The VOC and NO_x pollutants react in the presence of sunlight to form ozone (smog). The NO_x also combines with water vapour to form acid rain. While sulphur dioxide also contributes to acid rain, transportation is not a major source of this pollutant.

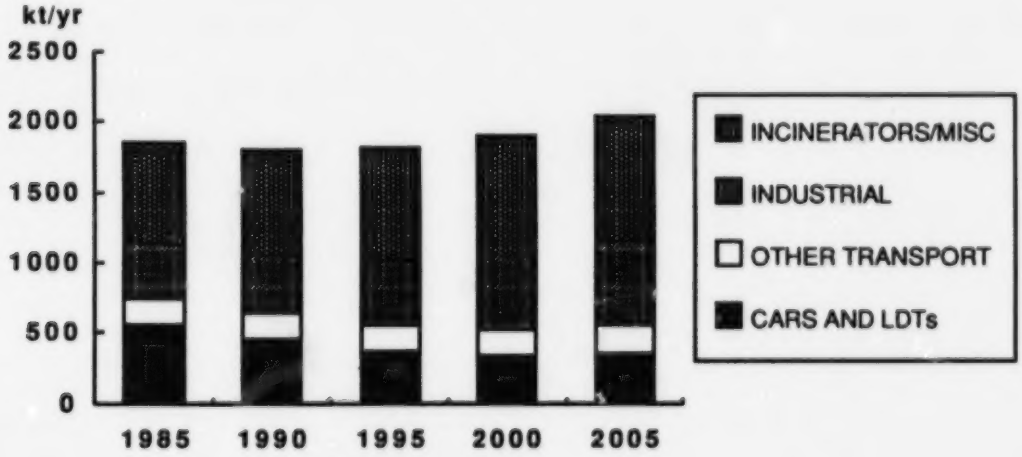


Figure 5/ Projected Canadian VOC Emissions

The production of VOCs and NO_x in Canada is shown in Figures 5 and 6. Both VOCs and NO_x are projected to increase steadily after 1990 and 1995 respectively. It should

be noted that during this period, the contributions from the power generation, incinerators, and industrial sources are projected to increase while those from road transportation will remain constant or decrease. The reasons for the decrease and the prospects for further decrease are discussed in section 4.1

The impact of the increasing trends in VOCs and NO_x is that some Canadian cities and regions exceed federal limits for ozone concentrations (82 ppb) and are facing problems of smog and acid rain. In addition, the rising production of CO_2 increases global warming and is viewed as an growing threat.

To address the threats posed by the continued production of these emissions, countries are passing regulations to control and limit their production. In Canada, the federal government, in cooperation with the provinces, has proposed a NOx/VOCs management plan to control these two pollutants. In the U.S., the Clean Air Act has been passed to control emissions from mobile and stationary sources. In the area of global warming, Canada and other countries are meeting to try to develop a policy to control the production of global warming gases.

To summarize some of the health and environmental effects of each emission, Table 1 shows which emissions contribute to global warming, smog, acid rain and general ground level pollution. Smog and ground level air pollution affect health.

	Global Warming	Smog	Acid Rain	Ground level Air Pollution
Carbon Dioxide	√			
Volatile organic compounds (voc)				
- Methane	√			
- Non-methane hydrocarbons	√	√		√
CFCs	√			
Oxides of nitrogen (NO_x)		√	√	√
Nitrous Oxide	√			
Carbon monoxide				√
Particulates				√

Table 1/ Atmospheric Pollution Contributions from Vehicle Emissions

3/ SOME ALTERNATIVE PERSPECTIVES

Now that some of the impacts of transportation on health, the environment, and energy demand are understood, we have to recognize the role that we, as transportation experts, can play in addressing these issues. As a first step, we must increase the importance of environmental and energy considerations in our transportation plans.

In fact, we must tightly integrate our transportation plans with environmental issues. We have to establish their importance relative to all of the other factors that go into making transportation decisions. The objectives of transportation plans should be in harmony with environmental plans in that they aim to increase transportation efficiency while reducing the production of pollution.

There are a range of measures, actions, and services that go into a transportation plan. Some of these measures are technological in nature, others affect lifestyle, while others are a combination of both. Some are provided at the local level, others are set or influenced by the provincial or federal government, while others can be provided by the private sector. Ultimately, we have to convince the public of the need to reduce pollution and to change their lifestyle and habits. However, in some cases, before we can do that, we may have to put in place a combination of alternative services, products, and incentives.

In the ongoing environmental debate, there is a continuing discussion to ascertain the role that advanced technologies versus a modified lifestyle can play in achieving a stable environment. It is a conflict and divergence of views that reflects, to some extent, the philosophical differences between the conserver and consumer society.

The perspective of the conserver society is to limit consumption and to strive for a lifestyle based on sufficiency rather than excess. It is a concept based on the 3 Rs, reduce, reuse and recycle. Along with this view, and some potential slowing of industrial activity associated with reduced consumption, is some implied reduction in the standard of living. However, others would counter that the conserver society would generate new activity and efficiencies, that the standard of living would not be affected and that there would be an overall improved quality of life.

On the other hand, the consumer society believes consumption need not be limited and that technology will provide solutions. The technology optimists have the view that society should be seeking technologically advanced solutions to solve our environmental problems and drive economic activity. The effort required to develop and produce these technological solutions will drive industrial activity and will result in a sustainable world with a higher standard of living. Further, these new technologies could then be exported to developing countries. One common example of a technological target is the non-polluting car of the future, powered by hydrogen or electricity derived from inexhaustible energy sources such as the sun or the fusion cycle. Photo-voltaic cells will supply the electricity to power our factories and homes.

Both of these views have some merit. However, since we are a long way from achieving the conserver society or the technology solutions required for the consumer society, the most pragmatic solution to follow today is one that embraces both ideas. We must promote and encourage both conservation and technological measures because both will be required. In the foreseeable future, neither approach alone will be able to achieve the changes that are necessary.

Let us examine what can be done in both the areas of technology and conservation to reduce emissions from transportation. The time frame for these thoughts are intermediate in length, i.e., 10 to 20 years

4/ TECHNOLOGY IMPROVEMENTS

4.1/ Vehicle Emissions

One of the main contributors to the production of pollutants is cars. As can be seen from Figures 5 and 6, the contribution to NO_x and VOCs will diminish from 1985 to the year 2005. This projection also accounts for the increase in vehicle population and VMT. The reduction is due to the stricter emission standards that came into effect in 1987 in Canada. Recognizing the need to further reduce emissions, significantly stricter standards have been set for vehicles for the period 1994 to 1996. Beyond that, standards have been proposed for a new class of vehicles called low emission vehicles (LEV) and ultra-low emission vehicles (ULEV) for California. The proposed emission standards for these cars are given in Table 2. The ability to manufacture vehicles with these stricter standards can only be achieved if improvements in the technology to deliver fuel to the engine and in the after-treatment of the exhaust gases can be developed. Technologies, such as the pre-heated catalyst, have already been demonstrated that will reduce emission levels below the 1996 standards.

The vehicle beyond the ULEV is called the zero emission vehicle (ZEV); it will be electrically powered. For this vehicle, the electricity will come from conventional power sources, i.e., nuclear, hydraulic, or fossil fuels. To determine the benefits of the ZEV vehicles on a global basis, the emissions from power plants will have to be compared with those from ULEVs.

	Current 1988	Proposed 1994-6	LEV 1997	ULEV 2000
Non Methane HC (g/mile)	**0.41**	**0.25**	**0.075**	**0.040**
Carbon Monoxide (g/mile)	**3.40**	**3.40**	**3.40**	**1.700**
Nitrogen Oxides (g/mile)	**1.00**	**0.40**	**0.20**	**0.200**
Cold Carbon Monoxide (g/mile)	**none**	**10.0**		

Table 2/ Current and Proposed Emission Standards for Cars

In reviewing the standards shown in Table 2, it should be noted that the two principal pollutants, hydrocarbons and nitrogen oxides, which are precursors for ozone, are reduced by factors of 10 and 5 respectively below the emission levels of today's vehicles. In addition to these new emission standards, new reformulated gasolines are being proposed which will have lower evaporative emissions. This will further reduce the loss of VOCs into the environment.

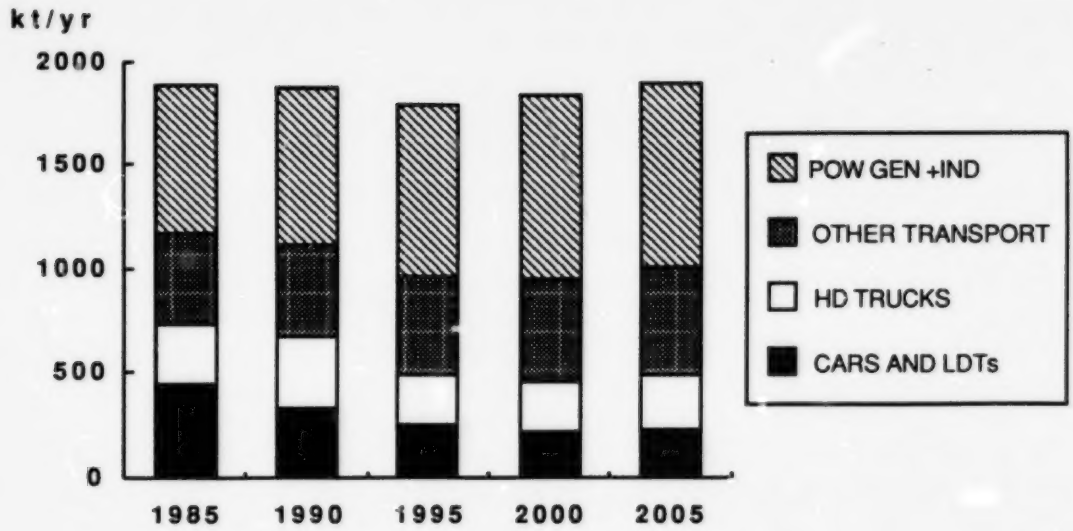


Figure 6/ Projected Canadian NO_x Emissions

In California the LEVs, ULEVs, and ZEVs will be slowly phased in over a period of years. The approximate introduction dates of LEVs and ULEVs are shown in Table 2. Each year the vehicles sold will have to meet a fleet emission average for non-methane hydrocarbons, i.e., VOCs. This concept is similar to that used for setting corporate average fuel economy standards. Beginning in 1998, 2% of vehicles sold in California must be ZEVs. If the ULEVs are to be introduced in the year 2002, significant reductions in NOx and hydrocarbons can be expected by 2010 because of the significant penetration of these vehicles into the fleet. In the year 2003, the fleet average emission for non-methane organic compounds for cars is set for 0.062 grams per mile.

4.2/ Alternative Transportation fuels

Alternative transportation fuels (ATFs) are being developed to address both the need for alternative energy sources and for clean fuels. These fuels can be used in both light duty vehicles and in heavy duty engines. The three most common ATFs are propane, natural gas, and methanol. In Canada, propane and natural gas were first introduced into the market by converting cars and light duty trucks. During a short period in the mid 80s, Ford and Chrysler sold factory modified propane cars. However, as the fear of another energy crisis faded, the demand for these vehicles declined and their continued production became uneconomic.

Also in the mid 80s, attention was focussed on the use of alternative fuels in heavy-duty engines, specifically their application in buses. The use of these fuels in transit was demonstrated in Canada in Ottawa (propane), Hamilton (natural gas), and Medicine Hat (methanol). The interest in these fuels was heightened by the need to meet strict emission standards for particulates and NO_x in diesel engines.

The new standards for buses, which were proposed in 1986 and revised recently in the U.S. Clean Air Act, are shown in Figure 7. As can be seen, emissions of particulates have to be reduced by a factor of 6 by 1994 and NO_x by a factor of 2. It was felt that the 1993 levels could be readily met with alternative fuels such as natural gas and methanol.

As a result, the Toronto Transit Commission, Mississauga Transit, and the Hamilton Street Railway have ordered 50 natural gas transit buses from Ontario Bus Industries. Transit Windsor has ordered 6 methanol powered transit buses from Motor Coach Industries. These transit systems will perform in-service evaluation of these fuels during 1991 to 1993. Recently, the transit bus diesel engine manufacturers have shown that the 1993 standard could be met with the use of low sulphur diesel fuel and a particulate trap.

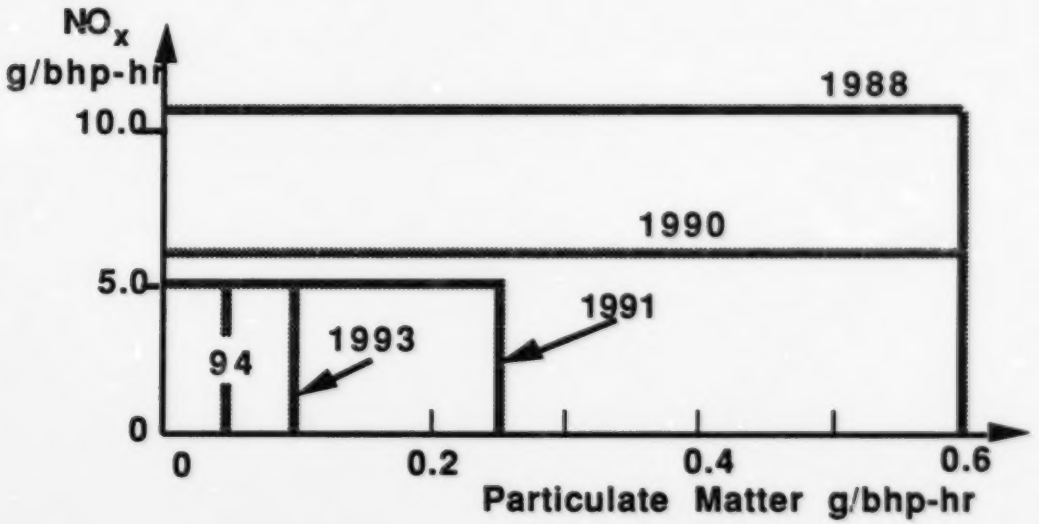


Figure 7/ Emission Standard for Diesel Buses

With the passage of the U.S. Clean Air Act, interest in alternative fuels has increased because of the need to supply vehicles to California in 1996. The auto makers are required to sell 150,000 clean fuel vehicles (CFVs) per year starting in 1996 and 300,000 in 1999 in California. Sales at the 1999 level would represent approximately 15% of all sales. At the current time the auto companies are looking primarily at the use of natural gas and methanol in cars and light duty trucks.

In addition to being introduced in California, CFVs will be introduced in 1998 into U.S. cities which are not in compliance with air quality standards. However, this could be postponed for three years if the emission standards proposed for the CFVs cannot be met for technological reasons. Depending on the number of cities that are not in compliance and other factors such as need to reduce the consumption of petroleum

fuels, state of development, and cost of technology, projected sales estimates of alternative fuelled vehicles in 2010 vary between 5% and 10% of total vehicle sales.

The emission standards to be met by the clean fuel vehicles are given in Table 3. It should be noted that the standards for the 2001 CFVs are the same as the 1997 California LEVs. This is a reflection of the need to learn more about the emission behaviour of alternative fuelled vehicles.

	1996	2001
Non Methane HC (g/mile)	**0.125**	**0.075**
Carbon Monoxide (g/mile)	**3.40**	**3.40**
Nitrogen Oxides (g/mile)	**0.40**	**0.20**

Table 3/ Emission Standards For Clean Fuel Vehicles

While it is assumed by many that CFVs will use methanol and natural gas for a fuel, the oil companies have been developing reformulated gasoline. This new fuel contains lower concentrations of benzene and aromatics, and adds about 2.7% oxygen. Also, to reduce evaporative emissions, the vapour pressure will be reduced from 9.0 psi to 7.8 psi. In addition to producing less pollution, the emissions from cars using reformulated gasolines are not as reactive and form less smog. Since low vapour pressure fuels cause hard starting on cold days, it is not known whether Canada could adopt such low pressure fuels uniformly across the country year round. However, since high smog levels occur mostly in summer, use of these fuels in summer only would be worthwhile. Early indications are that the use of reformulated gasoline and pre-heated catalysts will lead to cars that can readily meet the 1996 clean fuel vehicle emission standards

4.3/ Vehicle Fuel Economy

While a consensus has developed on the need for standards to reduce emissions from vehicles, no consensus has emerged on how to deal with new car fuel economy. While there is agreement that fuel economy standards should be increased, there is a considerable divergence of views with regard to the achievable level, the time frame, and the associated cost. However, while there are projected reductions for some vehicle emissions on the order of 5 to 10 relative to current standards, it is clear that no such improvements are projected for fuel economy over the near term. The maximum improvement expected in the average new car fuel economy is of the order of 33% over the next 20 years. Two such projections are given in Figure 8. These are taken from two recent studies on the potential for public policy measures to reduce carbon dioxide emission and provide background data for the U.S. national energy strategy (NES) [5,6].

The two projections for average fleet fuel economy are based on technological advances, economic factors such as fuel and vehicle cost, and increasing VMT per

capita. The two projections are business-as-usual scenarios in which fuel prices will slowly rise with time. It is likely that part of the increase will be due to taxes. However, looking at the current situation of low fuel prices, relative to Europe, there is little incentive for the public to buy fuel efficient cars. Also, without the demand, the manufacturers will not fund the research required to make the fuel economy improvements. Consequently, in the absence of economic incentives, an additional round of standards may be required to increase vehicle fuel efficiency.

Under the business-as-usual scenario for the next 20 years, fuel economy is expected to increase by 31% according to the NES study and 24% according to the DRI/McGraw-Hill study. Some allowance is made by NES for the introduction of alternative fuels. In the DRI/ McGraw-Hill report, the fuel economy is projected to increase by 1% per annum between 1990 and 2010. If we apply growth rates of VMT of approximately 2% over the next 20 years, the fuel economy gains are more than offset by the increase in VMT and as a consequence CO_2 emissions continue to grow.

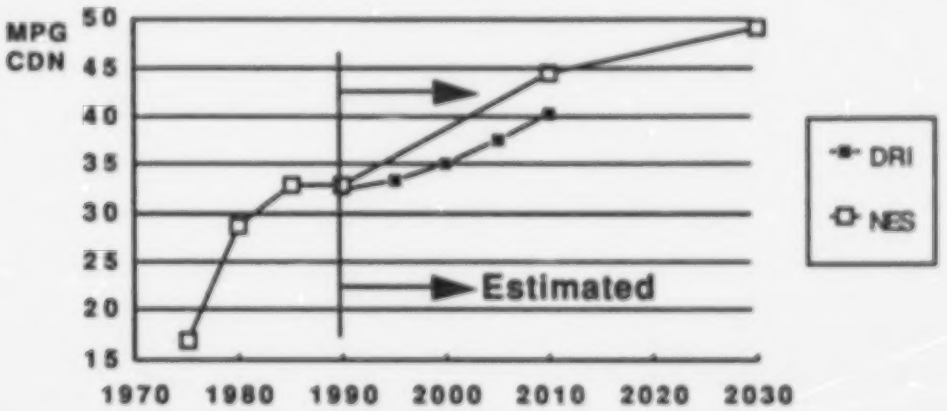


Figure 8/ Projected New Car Fuel Economy MPG

Clearly, efficiency gains based on current vehicle technology can only serve to slow the growth of the production of CO_2. To reduce the production of CO_2 more significantly, technological advances will be required to move us into the more advanced vehicles such as hybrids and then to the all-electric powered by energy from renewable resources.

4.4/ IVHS (Intelligent Vehicle/Highway Systems)

IVHS is receiving growing attention around the world as a means of achieving increased transportation efficiency and safety by considering vehicles and highways as an integrated system, and applying advances in informatics, electronics, and communications. The IVHS concept is very broad, ranging from advanced traffic management systems (signalized street networks and freeway management systems), to fleet management systems (trucking, buses), to advanced traveller information systems, to automated vehicle/highway systems. Such systems, by providing

improved efficiency, are projected to improve mobility and safety and support a healthy economy.

How IVHS will affect the energy consumed and emissions produced by transportation is less clear. Generally, in the short term, smoother traffic flow due to improvements in efficiency and reduction in congestion result in lower energy consumption and lower emissions. In the longer term, however, it will be necessary to ensure that land use and transportation developments are achieved in such a way that these benefits are not lost. Without appropriate management of land use and transportation demand, travel will adapt over time to the improved transportation efficiency provided, and the result may be increased energy consumption and increased emissions. That is, without management, the response to improved efficiency may be increased land use dispersion, longer trip lengths, and more VMT.

5/ LIFESTYLE CHANGES

Transportation planners and governments can influence people's lifestyle and the way the public uses transportation and transportation services. However, in order to accomplish this, alternatives must be provided. These alternatives include land use planning, increased availability of transit, car- and van-pools and bicycle paths. In addition, employers and all three levels of government can offer incentives and disincentives to make people change their transportation habits. Some of these measures are discussed below

5.1/ Land Use Planning

Research is being conducted into ways of providing a balanced urban transportation system in cities. In a balanced transportation system, cars, buses, trains, bicycles, and walking all play significant roles. In addition, the balance has to be developed between the need to provide an efficient and effective transportation system and one that minimizes the impact on the environment. A key component in determining this balance is the way land in an urban area is used. In future developments, land should be used in such a way that minimizes the transportation-induced environmental impact. How to achieve this will be a question of ever-increasing importance in the future.

Today there are three city concepts being discussed in which land is used differently. One can be described as the distributed city model in which there is no central core. Los Angeles is an example of such a city. The other two are based on the use of high density centres. In one case, there is only one high density centre while in the other, there are distributed multiple centres connected by transit systems. Today's planners seem to favour variations on the distributed centre concept. Seattle and Toronto are developing into distributed urban centres.

A recent systematic and detailed study of the world's cities by Kenworthy and Newman has revealed some of the characteristics of cities that affect how people use

transportation services [7]. In Figure 9, the gasoline used per capita per year is shown for the greater metropolitan areas of a sample of world cities. The use of gasoline is an indicator of the way people move within urban centres. High gasoline consumption indicates a preference for cars while low consumption indicates the high use of transit, walking, and bicycles. Kenworthy and Newman have studied 32 cities and have found some of the factors that determine the type of transportation that will or could be used. The criteria that they found could usefully describe cities are:

- Land Use Intensity
- Orientation to Non-Automobile Modes
- Level of Traffic Restraint
- Degree of Centralization
- Public Transportation Performance

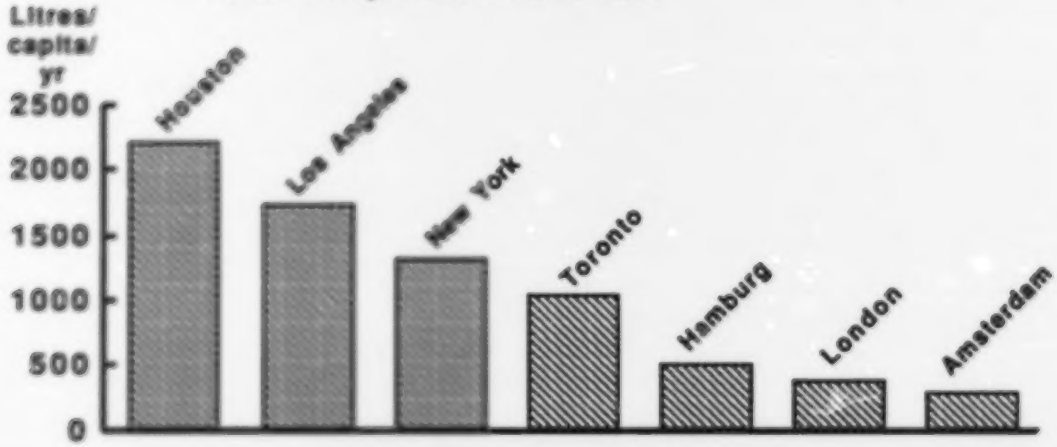


Figure 9/ Gasoline Use per Capita in Various World Cities

An example of the type of data that was collected and correlated is shown in Figures 10 to 12. While the figures of merit that were chosen by Kenworthy and Newman to correlate to each factor were more elaborate and extensive than those shown below, these simpler ones were strong contributors to their more elaborate variables.

Figure 10 shows the strong relationship between land use intensity, i.e. population and job density, and gasoline consumption. Kenworthy and Newman note in their study that the central city portion of New York, i.e. Manhattan, has a per capita energy consumption which is one quarter of that of the whole metropolitan city. The data in Figure 9 indicate that cities should be constraining growth in the outer areas and that jobs and population densities should be created in more compact urban forms.

The importance of public transportation in reducing gasoline consumption can be seen in Figures 11 and 12. Kenworthy and Newman found that fuel-efficient cities have extensive rail transit systems. It appears that rail transit systems attract people from their cars more effectively than do buses. That is not to say that bus systems

should not be encouraged. When combined with exclusive bus lanes or used on HOV lanes, they do attract riders and provide high quality service.

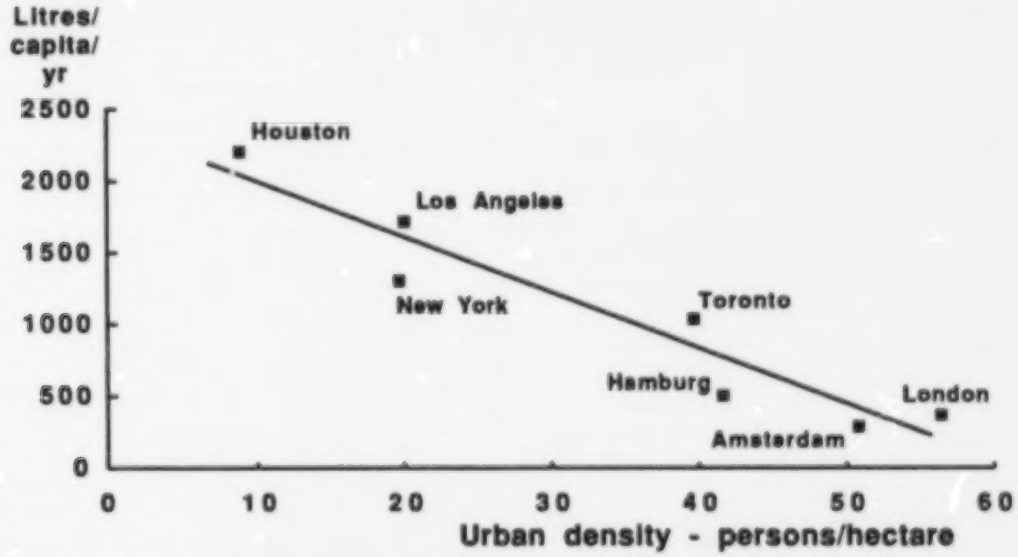


Figure 10/ Effect of Land Use Intensity on Fuel Usage

The data compiled by Kenworthy and Newman show how various factors can influence the average level of fuel used in an urban area. To make a city energy-efficient, their data suggest the need for increasing population and job densities in central areas, the need for distributed centres, and the importance of public transit. Their results also suggest that the amount of parking available in the central core areas should be controlled.

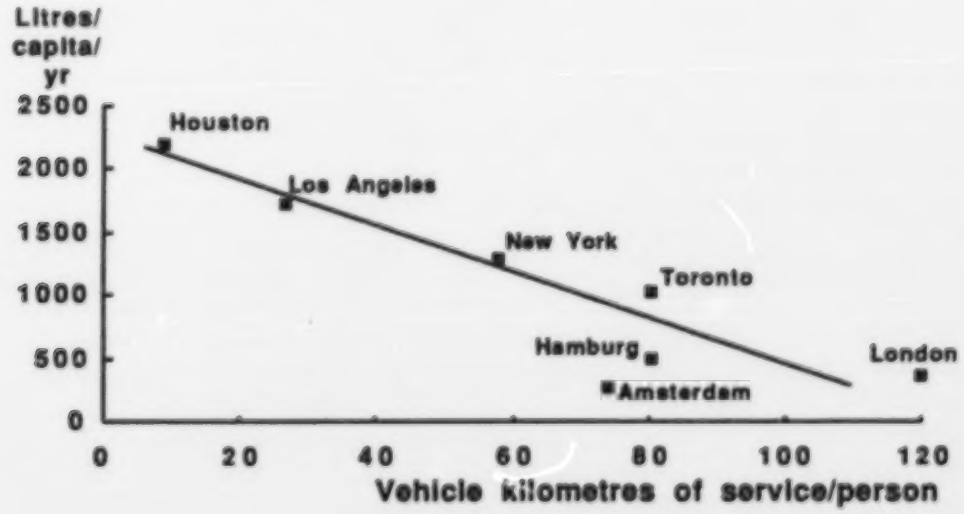


Figure 11/ Effect of Public Transit Performance on Fuel Usage

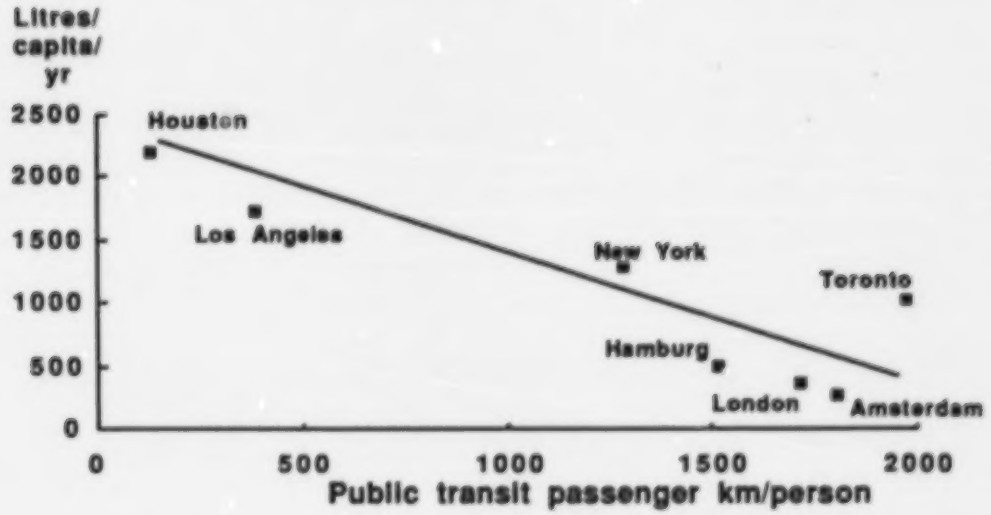


Figure 12/ Effect of Orientation to Non-Automobile Modes on Fuel Use

5.2/ Demand Management

While planners can affect job and housing locations through land use planning, other measures are required to alter the demand commuters put on the transportation system. To manage the demand, it may be necessary to provide incentives or disincentives to alter commuters' travel behaviour. These incentives/disincentives can be put in place by both governments and employers. There are various transportation demand management measures that can be considered, such as car- and van-pooling, subsidized transit fares, pay for parking, and fuel taxes. The impact of parking fees and fuel taxes on driving habits are discussed below.

5.2.1/ Parking Fees

The use of parking fees to reduce the use of single-occupant cars is one of the measures being demonstrated in some cities that have both congestion and air quality problems. The availability of parking and its cost is viewed as one of the factors that has significant impact on whether cars are used for commuter trips. In many cases employers provide free parking but no incentive to use transit or other modes such as car- or van-pooling. In some cases where bus passes are provided, the benefits are taxed while free parking goes untaxed.

In one test case in California, an employer who was providing a tax-free $55 per month parking allowance and fully subsidized transit passes has restructured the benefits program to try to encourage some form of ridesharing. A basic taxable transportation allowance of $40 per month is now being provided to all employees. In addition, bonus payments are paid to those who choose an alternative mode of travel

to the single-occupant automobile. The result is that the average vehicle occupancy rate of cars travelling to this site increased from 1.51 to 1.67. The percentage of employees who car-pooled increased from 43% to 49%. No change occurred among employees who took transit or van-pooled. This case gives some indication of the magnitude of change that can be achieved by incentives. Some studies indicate that transportation demand measures can achieve a 10% to 15% reduction in demand.

5.2.2/ Public Policies

One of the more serious and long-term environmental issues facing the world is global warming. In order to control global warming, many countries are meeting to reach a consensus on the targets that should be set to control the production of CO_2. Two commonly discussed targets are stabilization of CO_2 production by the year 2000 at the 1988 level and reduction of CO_2 production levels to 20% below the 1988 level by the year 2005. After accounting for growth, the latter goal represents a 50% reduction below the projected production levels in 2005 in a business-as-usual environment. According to the UN IPCC report, to stabilize CO_2 concentration at today's levels, man-made production of CO_2 has to be reduced by more than 60%. This target is considerably higher than the ones currently being considered.

The Ontario Ministry of Transportation, along with the ministries of Environment and Energy, conducted a study to determine the range of necessary steps required to achieve the stabilization and 20% CO_2 reduction goals in the transportation sector [3]. The study found that to achieve the first target, i.e. stabilizing CO_2 production at 1988 levels, the following range of actions would be required:

- Car and truck average fuel efficiency would have to improve by 26% and 13% respectively by 1995
- Average public transit modal split in Ontario would have to realistically increase to 16% from the current level of 9%
- A carbon tax of an additional 31% would have to be imposed by the year 2000 to improve fuel efficiency by 16% and reduce travel demand by 3%
- Restrictions on car use would have to be imposed to reduce travel demand by 5%
- Urban traffic management measures would have to be implemented to improve urban fuel efficiency by 5%.

To achieve the second target of a 20% reduction by the year 2005, the following more severe actions would be required:

- Car and truck average fuel efficiency would have to improve by 32% and 14% respectively
- Average public transit modal split in Ontario would have to optimistically increase to 22% from the current level of 9%
- Land use planning would have to be implemented to reduce urban travel demand by 10%
- A carbon tax of 109% would have to be imposed by 2005 to improve fuel efficiency by 38% and reduce travel demand by 5%
- Car use would have to be restricted to reduce travel demand by 20% to 30%
- Urban traffic management measures would have to be implemented to improve urban fuel efficiency by 5%

As can be seen, rather severe changes in lifestyle and modal shift and significant technological advances in cars and trucks would be required to achieve either one of these targets.

In the U.S., a similar but more specific study was carried out for the EPA by DRI/McGraw-Hill. In the study, the impact of specific policy measures on the use and purchase of light vehicles was investigated. One of the policy measures studied was the level of gasoline taxes required to achieve stabilization in CO_2 emissions from light vehicles at the 1989 levels for the next 20 years. A related policy study tried to achieve a 20% reduction in CO_2 emissions from light vehicles by the year 2000. The required taxes in cents per gallon (1989 U.S. dollars) are given in Table 4.

	1989	1995	2000	2005	2010
Base Case	9.0	14.6	19.6	26.4	26.4
Holding CO_2 Emissions 'evel	9.0	40.0	70.0	105.0	155.0
Reducing CO_2 Emissions 20%	9.0	125.0	250.0	375.0	475.0

Table 4: Estimated U.S. Federal Gasoline Taxes for Two CO_2 Reduction Scenarios

As can be seen, very significant taxes have to be imposed to even hold CO_2 emissions from light vehicles at 1989 levels. Also the taxes have to continue to increase over the time period.

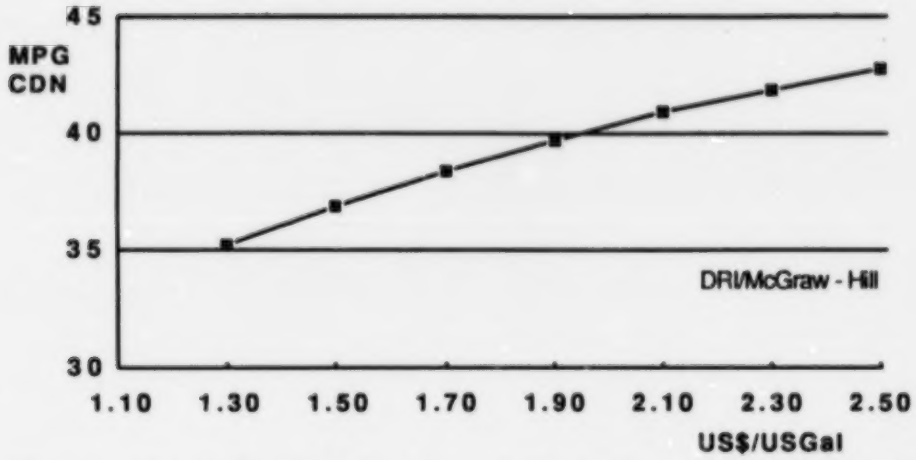


Figure 13/ Estimated Impact of Fuel Cost on Average Fleet Fuel Economy of Cars

The study also showed how the average fleet fuel economy in the year 2000 would increase if the gasoline taxes were increased. The results are shown in Figure 13. For this case, $1.30 U.S. was taken as the average fuel price and 35 mpg in the year 2000 was taken as the reference fuel economy. The results indicate that a gasoline tax of 62¢ per gallon would result in an average fuel economy increase of 5 mpg. It is interesting to note that the difference in price between U.S. and Canadian gasoline is about 50¢ U.S. per gallon. However, the difference in the average fuel economy of cars between Canada and the U.S. is about 1 mpg. Similarly, while European fuel prices are typically above $3.00 U.S., the difference in fuel economy is approximately 3 mpg between Europe and the U.S. This may lead one to conclude that the impact of taxes on average fuel economy is being over estimated. However, one should not take these U.S. projections and readily apply them to other countries because many other historical and economic factors affect car buying habits. Perhaps this indicates that government standards are required to complement the economic measures.

6/ CONCLUSIONS

1/ Transportation demand will continue to rise as the economy expands. Along with this, some emissions such as CO_2 will continue to increase. However, others will decrease due to advances in technology.

2/ The importance of environmental and energy considerations in transportation plans must be increased. It is important to tightly integrate transportation plans with environmental goals.

3) To reduce damage to the environment from transportation, a combination of lifestyle changes and technological advances must be pursued. However, for

lifestyles to change, effective alternative transportation services, such as transit, van pools, and HOV lanes, must be provided.

4/ Another component in minimizing the impact of transportation on the environment is the provision of clean and efficient vehicles. Such vehicles would have a high fuel economy and would use clean fuels such as methanol, natural gas, propane, or reformulated gasoline. By setting standards to promote the efficient use of energy and to control emissions, governments can advance the introduction of such vehicles.

5/ In providing transportation facilities for more efficient traffic flows, appropriate land use planning is important to maintain the initial environmental and efficiency gains. For the longer term, it will be necessary to ensure that land use and transportation developments are achieved in such a way that these benefits are not lost. Without appropriate management of land use and transportation demand, travel will adapt over time to the improved transportation efficiency provided, and the result may be increased energy consumption and increased emissions. That is, without management, the response to improved efficiency may be increased land use dispersion, longer trip lengths, and more VMT.

References

[1] Management plan for Nitrogen Oxides and Volatile Organic Compounds, Canadian Council of Ministers of the Environment, March 1990.

[2] Report on reducing greenhouse gas emissions, Federal/Provincial/Territorial task force on energy and the environment, August 1989.

[3] Reduction of energy use and emissions in Ontario's Transportation Sector, VHB Research & Consulting Inc., McCormick Rankin, Pilorusso Research Associates Inc., April 1991.

[4] The Clean Fuels Report, J.E. Sinor Consultants Inc., June 1991.

[5] An analysis of public policy measures to reduce carbon dioxide emissions from the U.S. transportation sector, DRI/McGraw-Hill, January 1991.

[6] Energy consumption and conservation potential: Supporting analysis for the national energy strategy, National Energy Strategy, SR/NES/90-02, Energy Information Administration.

[7] Learning from the best and worst: Transportation and land use lessons from thirty-two international cities with implications for gasoline use and emissions, Transport research paper 7/87, School of environmental sciences, Murdoch University, Perth, Western Australia, J.R. Kenworthy and P.W.G. Newman.